THE INTERACTION BETWEEN CAFFEINE AND ESTROGEN ON SHORT-TERM MEMORY RECALL

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ABSTRACT

An experiment was conducted to examine the potential interaction of caffeine and estrogen on short-term memory recall, in female subjects. Thirty eight subjects were tested for their short-term performance on an audio-taped, word-list recall task, following classification as being either at the beginning or middle of their menstrual cycle, and after being given either 0 or 4mg of caffeine per kilogram of body mass to drink. Subjects also completed the Eysenck Personality Inventory, in order to assess their extraversion score, as well as a self-reported, regular caffeine intake questionaire, and a state-response questionaire.
Previous studies of this kind have reported a sex difference in recall performance, indicating that caffeine's influence on recall ability varies between the sexes. In response to this, it has been postulated that the gonadal hormones, with particular reference to estrogen, may modify the effects of caffeine on short-term recall. Thus, in this particular study, it was predicted that the effect of caffeine on the recall performance of female subjects would differ according to their menstrual cycle stage. It was also predicted that subjects tested at mid-cycle, would have a natural recall superiority to subjects tested at the beginning of their cycles.
The results of this study found firstly, that contrary to expectations, mid-cycle subjects under the placebo condition had an inferior recall performance to menstruating subjects. It was also found that oral administration of the 4 mg/kg caffeine compensated for this disadvantage. This pattern of results was further complicated firstly, by subjects' regular caffeine consumption, and secondly, by subjects' degree of extraversion. Specifically, subjects classified as high caffeine consumers did not display the menstrual-recall advantage of other subjects, whilst subjects with above -average extraversion scores, tended to have lower recall-scores than subjects with below-average extraversion scores. Whilst these findings have some interesting implications regarding the factors which influence short-term recall ability, they must be regarded cautiously, because of a number of short-comings in the present study. It is suggested that this study be repeated using a much larger subject size, and over a longer period of time.

CHAPTER ONE

INTRODUCTION

THE INTERRELATIONSHIP BETWEEN CAFFEINE, ESTROGEN, AND SHORT-TERM RECALL

As will become clear to the reader during the course of this thesis, until recently there have been few investigations of the effects of the sex hormone estrogen, on cognitive functioning. In contrast, there exists an ample body of literature related to caffeine's influence on cognitive performance. Generally, caffeine has been found to alter subject task performance, but it is clear that the nature of this relationship is somewhat confounded by other factors relating to personality differences, environmental influences, and the specific requirements of the task. (Erikson, G.E., Hager, L.B., Houseworth, C, Dungan, J., Petros, T., and Beckwith, B.E., 1985; Arnold, M.E., Petros, T.V., Beckwith, B.E., Coons, G. and Gorman, N., 1987).

Of prime interest to the present author is the intriguing finding of sex differences, in caffeine's influence on short-term memory recall (Arnold et al, 1987; Erikson et al, 1985). It was suggested by Arnold et al (1987), that this gender difference may be due to an interactive effect between caffeine and the gonadal hormones, with particular reference to the estrogens. Estrogens, along with caffeine, have been shown by researchers to have an excitatory effect on the autonomic and central nervous systems (Broverman, 1981).

Relatedly, it has long been advocated by theorists such as Eysenck (1987), that recall ability, similar to other cognitive performance, is partly a function of subject arousal levels. Specifically, it has been postulated that the relationship between performance and arousal is curvalinear (, an inverted U), with a moderate level of arousal being ideal for cognitive performance (Broaadhurst,1959; Duffy,1972).

Thus, in the context of the stimulatory roles of estrogen and caffeine; the present study was designed to investigate the interactive influence of these agents on a short-term recall task. Individual differences with regard to arousal levels and possible tolerance to the effects of caffeine were also considered.

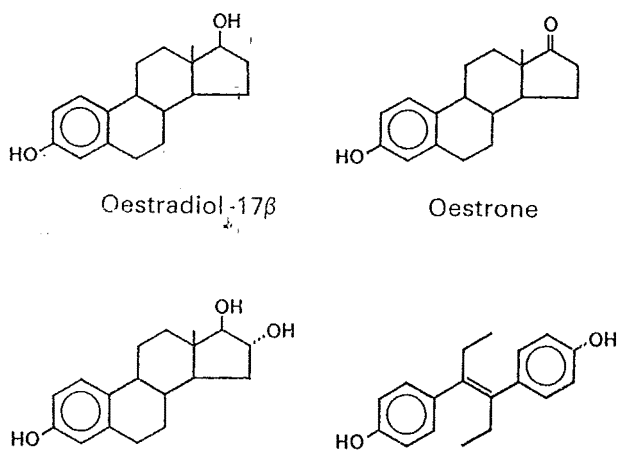
REVIEW OF THE LITERATURE

ESTROGEN

The Nature of Estrogen

Estrogen (or oestrogen) is a generic label which incorporates a number of related steroid hormones produced primarily by the ovaries, but also by the adrenal cortices and, in very small amounts, by the testes (Reber, 1985; Carlson, !986). Included in the group of estrogens are estradiol, estrone, and their metabolic product; estriol. Estrogens are also capable of being synthesised, as in the case of diethystilboestrol (Jensen, 1979). These hormones are of principal importance to reproductive processes in the female (Jensen, 1979). Figure One (from Jensen, 1979), provides an illustration of the chemical structure of some natural and synthetic estrogens.

Figure One: Chemical Structures of Some Natural and Synthetic Estrogens (,from Jensen,1979).



Oestradiol-17β Oestrone

Oestriol Diethylstilboestrol

Structures of some natural and synthetic oestrogens

During the reproductive years, the principle estrogen in women is estradiol 17*B,* produced from cholesterol in the ovary under stimulation by gonadotrophic hormones from the anterior pituitary (Jensen, 1979). In the liver and elsewhere, circulating estradiol is converted in large part to the less active substance, estrone; which, along with estriol derived from it, represents a major urinary excretion product.

In postmenopausal women, where ovarian production of steroids has decreased, estrone is the main estrogen, derived from the peripheral conversion of 4-androstene-3,17-dione originating in the adrenal glands (Jensen, 1979).

During human pregnancy, the feto-placental unit produces substantial amounts of both estradiol and estrone, as well as estriol, particularly during the last trimester. In men, estradiol is secreted by the Leydig cells of the testis, in amounts roughly one-fifth of that produced in non-pregnant women (Jensen, 1979).

The Physiological Actions of the Estrogenic Hormones

Estrogens are responsible for the development of most of the female secondary sex characteristics, breast development, maturation of the genitalia and deposition of body fat (Carlson, 1986). They also influence sexual behaiour (Jensen, 1979).

The ovarian production of estrogens varies periodically, so that in addition to maintaining the reproductive tissues on their adult form, estrogens cause intermittent episodes of intensive stimulation, especially in the uterine and vaginal linings (Jensen, 1979), and are

responsible for the cyclic changes in the uterus that accompany the menstrual cycle (Carlson, 1986).

As with other gonadal hormones, estrogens exert an inhibiting action on the hypothalamus and anterior pituitary gland, thereby causing feed-back regulation of the level of gonadotrophins that stimulate their production by the ovary (Jensen, 1979).

Estrogen Fluctuations Over the Menstrual Cycle

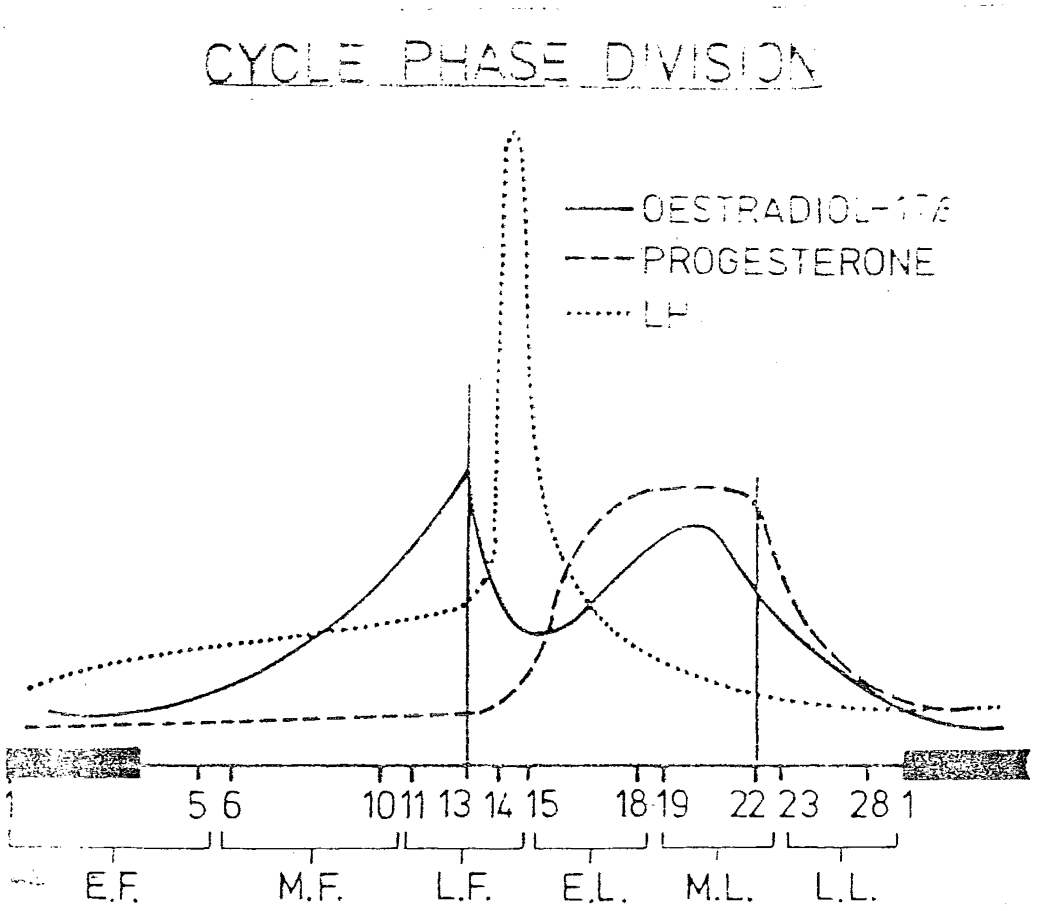
(For a comprehensive summary of the menstrual cycle itself and the cyclical hormonal changes which occur, see Gamby (1989) or Sanders (1981).

It must be stressed, that because the menstrual cycle is so variable in length; duration of phases; and levels of hormones (Sanders,1981), exact specification of the timing of hormonal events is only possible with direct physiological data. Thus, the following description of estrogen activity can only be appropriately regarded as an estimate for each particular menstrual cycle.

During the early-follicular or menstrual phase of the cycle (days 1-5), estrogen levels are at their lowest level for the cycle. In the mid follicular phase (days 6-10), estrogen levels begin to rise, and reach a peak during the late follicular phase (days 11-14); followed by a fall during the early luteal phase (days 15-18). A second estrogen peak occurs during the mid-luteal phase (days 19-24). This however, is pharmacologically counteracted by a corresponding peak in progesterone (Sanders,1981). During the final stage of the menstrual cycle; the late luteal phase (days 25-28), estrogen levels drop again. Figure Two (from Sanders, 1981), illustrates the typical variations in estradiol, the most

potent estrogen, over the menstrual cycle.

Figure Two: Graphic Illustration of Typical Variations in Estradiol, Progesterone and L.H. over the Menstrual Cycle



KEY

E.F.	Early Follicular	Phase
M.F.	Mid	"
L.F.	Late	"
E.L.	Early Luteal	"
M.L.	Mid	"
L.L.	Late	"

Estrogen's Influence on Cognitive Ability

The neurological basis.

There is some experimental evidence to suggest that the performance of automatised tasks, such as the immediate word-list recall required in the present study, is enhanced by adrenergic stimulants such as amphetamine and caffeine (Broverman and Vogel,1985) . Automation tasks are those which require quick and accurate responses to well-learned tasks, in contrast to tasks which require perceptual restructuring (Cooper, Blue, and Ross, 1983). Since estrogen has also been postulated to act as an adrenergic stimulant (Broverman, 1981); it can be assumed to have a similar influence on the performance of automatised tasks, and thus enhance short-term recall.

Broverman, Klaiber and Vogel (1980), for instance, suggest that the well-documented superiority of females on automatisation tasks, and their converse inferiority to males on perceptual-restructuring tasks, is due to a greater potency of estrogen as an adrenergic stimulant. Perceptual-restructuring tasks are thought to require an inhibition of immediate responses to obvious stimulus attributes in favour of responses to less obvious stimulant attributes. It has been hypothesised (Broverman et al, 1980), that these sex differences are reflections of differences in relationships between adrenergic activating and cholinergic inhibitory neural processes, which, in turn, are sensitive to the sex hormones, androgens, and estrogens.

Specifically, it has been postulated (Broverman, Klaiber, Kobayashi and Vogel, 1968), that the performance of perceptual-motor tasks, such as the one used in the present study, may be facilitated by the activating

influence of the sympathetic subcortical nervous system. In contrast; performances of inhibitary perceptual-restructuring tasks, such as finding embedded figures, are presumed to be impaired by activation of the sympathetic, and facilitated by the activation of the parasympathetic subcortical nervous system (Broverman et al, 1968).

Thus, any alteration in the activation-inhibition balance between the sympathetic and parasympathetic subcortical nervous system, by the administration of sympathetic nervous system stimulants such as estrogens, would tend to facilitate perceptual-motor task performance.

Several physiological mechanisms that might enable estrogen to produce adrenergic stimulation have been postulated. It has been reported, for instance, that in female mice, estrogens are associated with an increased synthesis of brain norepinephrine (NE), an adrenergic neurotransmitter (Broverman and Vogel, 1981). Additionally, the metabolites of estrogen have been reported to retard the rate of extraneuronal degradation of NE, with a subsequent potentiation of NE effects (Broverman and Vogel, 1981). Finally, estrogens have been reported to inhibit the activity of monoamine oxidase (MAO), an enzyme that destroys NE intraneuronally (Broverman and Vogel, 1981).

Thus, each of these estrogenic influences would have the result of enhancing CNS adrenergic functions. Although this theory has been criticised on logical and philosophical grounds (Broverman and Vogel, 1981), empirical research tends to support it.

The empirical evidence linking estrogen activity to sensory and cognitive performance.

The experimental literature provides strong support for a relationship between subjects' performance on sensory and cognitive tasks, and estrogen activity.

It has been reported for instance (Ward, Stone and Sandman, 1983), that sensory sensitivity fluctuates over the course of the menstrual cycle, as levels of both estrogen and progesterone vary. For example, Diamond, Diamond, and Mast (1972), found that visual sensitivity was lowest for normally cycling females during menstruation (,when estrogen levels are low), progressively increasing until ovulation (,when estrogen levels are at a peak), and remaining elevated for the duration of the cycle. Relatedly, in Kopel et al's (1969) study, female subjects tested premenstrually showed a tendency towards inaccurately-high values for time estimation and two-flash threshold tasks. The same result was not found with ovulating subjects. It was suggested by these researchers that a premenstrual impairment of perceptual ability may reflect a general state of slowing of the internal clock,or lower arousal at that time. This postulaion is supportive of the idea that estrogen causes increased subcortical arousal, since estrogen levels are low premenstrually.

Moreover, further empirical evidence is provided by Wong and Tong (1974), who found no fluctuation of sensory and criterion scores in a group of subjects taking oral contraceptives, suggesting a relationship between sensory ability and gonadal hormone levels. Further evidence supportive of a link between gonadal hormonal activity and cognitive-sensory ability is provided by Lamb, Masters and Robinson,

(1953), who found that EEG changes in response to photic stimulation, were related to menstrual cycle fluctuations.

As regards the facilitative influence of estrogen on automation tasks specifically; the experimental literature offers considerable support for this relationship. For instance, Peterson (1976), studied the correlation between anthropometric indexes of gonadal hormone stimulation and cognitive functions in young women, and reported that female subjects with body builds indicative of greater estrogen stimulation, had significantly stronger automatisation cognitive patterns than those with body builds suggestive of lesser estrogen stimulation. Similarly, a study carried out by Cooper, Blue and Ross, (1983), found that the automation performance of women who were expecting to menstruate in 11-15 days and therefore whose estrogen levels would presumably be high, was better than that of male subjects. Other studies, for example, Broverman et al (1981), also indicate that high levels of estrogen are positively correlated with performance on automation tasks, and conversely, negatively correlated with performance on tasks that require complex perceptual restructuring.

Yet stronger evidence supporting the role of estrogen in cognitive performance comes from a study carried out by Fedor-Freybergh and Dornic (1975), where estrogen treatment reportedly improved female subjects' concentration ability and short-term memory.

EYSENCK'S EXTRAVERSION PERSONALITY TRAIT AND ITS RELATION TO THIS STUDY

Extraversion as a Personality Trait

In personality theory, the term extraversion (E) refers to the tendency to direct one's energies outward, and to seek gratification from the physical and social environment (Reber, 1985; Revelle, Anderson and Humphreys, 1987). The prototypical extravert is less inhibited in emotional expression than the characteristic introvert (Eysenck, 1968). Every affect, every emotional-conative excitement, readily flows out from the subcortical levels into outward expression instead of being largely drained off to and absorbed into the cortex (Eysenck, 1968).

In comparison, introverts (I) tend to be introspective and to shrink from social contacts (Reber,1985). According to Eysenck (1968); in the marked introvert, the inhibition normally exerted by activity of the cerebral cortex on all lower nervous functions is manifested in high degree. Of these lower inhibited functions, the most important are the affective or emotional-conative functions of the thalamic region. In introverts (, according to Eysenck), this affective energy is diverted from bodily expression and long-circuited to and through the cortex, where it co-operates in substaining the activities of reflective thinking, a process which results in the simultaneous excitation of various affective tendencies which partially check or neutralise one another so far as external expression is concerned.

According to traditional Extraversion-Introversion theory, these two

phenomena were postulated as representing two unitary personality types with one being the complete antithesis of the other (Reber,1985).

However, contemporary theorists tend to doubt that either phenomenon exists as a singular type and instead regard both as collections of a number of different patterns of behaviour (Reber, 1985). Neither does it seem plausible that the two poles can be validly regarded as opposites as it is common for persons to increase their repertoire of behaviours along one pole without necessarily decreasing along the other (Reber, 1985).

The Relation of the Extraversion Scale to this Study

In accounting for the variables which confound the relationship between caffeine intake and short-term memory performance, there is evidence to suggest that the role of subjects' extraversion scores should be considered. For instance, Eysenck (1967) argues that behavioural differences between introverts and extraverts are a manifestation of a basic difference in physiological arousal, and that under identical conditions of external stimulation, introverts will display higher levels of physiological arousal than will extraverts. This theory has the support of some subsequent researchers. Smith, Rypma and Wilson (1981), for instance, found that introverts' performances on an electrodermal orienting response task reflected higher levels of cortical arousal than that of extraverts.

Thus, since caffeine can validly be regarded as a form of external stimulation (,see the following section on the physiological effects of caffeine), then one would predict along with Eysenck (1967), that the administration of caffeine should result in differental levels of arousal

for introverts and extraverts, and therefore in differences in the efficiency of performance.

Or, to put it another way, Eysenck (1968), regards stimulant drugs, such as amphetamine and caffeine, as having an introverting effect, and depressant drugs, such as sodium amylobarbitone, as having an extraverting effect. If introversion-extraversion is linked with level of arousal, these drugs are seen as having, respectively, an arousing and de-arousing effect.

In accordance with this prediction, past research (Gilliland,1980; Revelle et al, 1976; Revelle et al,1980) has generally demonstrated that the effects of caffeine are dependent upon a subject's typical level of physiological arousal, as indexed by the Eysenck Extraversion scale. In a study carried out by Gilliland (1980.) for instance, extraverts' performances on a test of verbal ability after consuming 0, 2, or 4 mg caffeine per kg of body mass, improved as the dose of caffeine increased. In contrast to this, introverts' performances increased between the 0 and 2 mg/kg conditions, and then decreased between the 2 and 4 mg/kg conditions.

Subsequent work has provided further substantial support for the validity of this proposed introversion/extraversion by caffeine interaction (Revelle et al,1980, Smith, Rypma and Wilson, 1981). For example, Revelle, Amaral and Turriff (1976), reported that the administration of moderate doses of caffeine impaired the performance of introverts and facilitated that of extraverts on a cognitive task. Of especial relevance to the present study, Humphreys et al (1984), suggested that a high level of arousal should impair performance on tasks that place heavy demands on short-term memory capacity, such as prose

memory or word list recall. Thus, it is abundantly clear from the literature that any study of the effects of caffeine on a cognitive task such as short-term memory recall, needs to take into account the mediating role of subjects' resting levels of cortical arousal. It is specifically because of this that this present study included a a measure of each subject's Extraversion score, as measured by The Eysenck Personality Inventory.

THE PHARMACOLOGICAL ACTION OF CAFFEINE ON THE CENTRAL NERVOUS SYSTEM, AND ITS RELEVANCE TO THIS STUDY.

There are already in existance a number of comprehensive reviews of the history of caffeine use; its general pharmacological properties and its extensive influence on human behaviour. Subsequently I will not be discussing these aspects of the drug in any great detail, but instead refer the reader to any of the comprehensive reviews of caffeine produced by researchers such as Shanahan (1982) or Whitley (1985). My focus in this section will be instead on issues which have specific relevance to the present study: firstly, our culture's caffeine consumption habits, and secondly, caffeine's influence on mood, and sensory and cognitive ability.

Caffeine as a 'Social' Drug

In Western Society, frequent consumption of caffeine is a widespread phenomenon. It is common practice, for instance, for a person in our culture to begin the day with a cup or more of tea or coffee (Murray, 1988). Most work places have regular 'coffee breaks', with the provision of coffee and tea for workers written into industrial awards (Murray, 1988). Caffeine-containing substances also function widely as social lubricants. In addition, caffeine is found in some over-the-counter medications, such as stimulants, analgesics and cold preparations (Shanahan, 1982). Thus, because caffeine is such a widely used drug, the recent growth of related academic literature reflects a corresponding interest in its effects on the human body.

The Effects of Caffeine on the Central Nervous System (CNS)

Caffeine is an alkaloid with a xanthine nucleus. Pharmacologically, it is known as 1-3-7 trimethylxanthine (Shanahan, 1982). Some substances contain other xanthines as well as caffeine; for example, tea and chocolate contain theobromine. Tea also contains theophylline (Burg, 1975; Martinek, 1955; Shanahan, 1982). The xanthine family of substances all have stimulant properties (Shanahan, 1982).

Caffeine is a potent stimulant of the CNS (Murray, 1988; Boulenger and Uhde, 1982; Zahn and Rapoport, 1987), primarily affecting the cerebral cortex, the thalamus, the vasomotor and respirarory centres and the thermal regulatory mechanism (Reimann, 1967; Murray, 1988).

The first parts of the CNS to be affected by caffeine are the medullary centres and the cerebral cortex, followed by the brainstem. Stimulation of the brainstem by caffeine occurs only after extremely high doses (2-5gm) (Goldstein et al,1965; Ritchie,1970; Truitt, 1971). Although it is theoretically possible for convulsions and death to result from consuming extremely high doses of caffeine; in practice the possibility of this happening is very unlikely, as it would require a dose equivalent to about 100 cups of coffee (Shanahan,1982).

In terms of its more commonly-experienced effects, doses as small as 100-150mg of caffeine are sufficient to cause the predominant and earliest effects on the cerebral cortex (Martinek,1955; Burg,1975), and include rapid, clear thinking, enhanced intellectual alertness, wakefulness and increased memory span (Shanrahan, 1982). The effects of 100-300mg of caffeine on sensorimotor functions include increased

attentional performance (Clubley, Bye, Henson, Peck and Riddington, 1979; Elkins et al, 1981), and improved stimulus discrimination (Craig, Humphreys, Rocklin, and Revells,1979). Thus, small doses of caffeine can be interpreted as having beneficial effects on performance.

In terms of subjective influence, small doses of caffeine have been reported to have beneficial effects on arousal and mood. Delayed experience of tiredness and drowsiness (Ritch,1970; Lienert and Huber,1966), and subjective arousal (Barmack,1940; Goldstein and Kaizer,1965), have been reported after the consumption of 150-300mg of caffeine. Clubley, Bye, Henson, Peck and Riddington (1979) reported subjective arousal with as little as 75mg of caffeine; a dose where effects on performance tests wouldn't show. The intake of 65-100mg of caffeine results in slight mood improvement (Cameron, Specht, and Wendt, 1967), including increased extraversion and calmness.

In contrast, symptions of anxiety, nervousness, irritability and agitation have been reported after the ingestion of 300-600mg of caffeine (Julian,1981).

Thus, as substantiated by the experimental literature, doses of caffeine up to about 300mg, have been demonstrated to usually have beneficial effects on intellectual functions, sensorimotor abilities, arousal and mood (Shanahan, 1982). (In the present study, non-placebo subjects received doses of caffeine at the rate of 4 mg per kg of body mass. Therefore, since subject- weight for this experimental condition fell between the ranges of 52 and 70 kg, these subjects would have each ingested a dose of caffeine of between 208mg and 280mg.)

The Influence of Habitual Caffeine Consumption

However, it does need to be stressed that these effects are not uniformly experienced, and are mediated by each individual's history of caffeine consumption. Long-term, heavy coffee and tea drinking can result in the development of tolerance to some of caffeine's acute effects (Shanahan,1982). Moreover, the chronic use of caffeine can produce its own particular symptoms in consumers (Murray, 1988). Thus, it is important to take each subject's habitual intake of caffeine into account (, as has been done in this study),when analysing its acute effects.

Boulenger and Uhde (1982), and Boulenger, Uhde, Wolff and Post (1984), for instance, found a significant association between caffeine consumption and scores of self-rated trait anxiety and depression in samples of college students and psychiatric inpatients. Moreover, normal adults and psychiatric inpatients who consume more caffeine than the average population, tend to score higher on state-trait anxiety tests (Murray,1988; Greden, Fontaine, Lubetsky, and Chamberlin, 1978; Winstead, 1976). Similarly, a study by Veleber and Templer (1984), found that consumption of moderate (250mg) doses of caffeine increased anxiety, depression, and hostility.

Paradoxically however, somatic symptoms of anxiety seem to be reported more frequently by those who show low caffeine consumption (Boulenger, Uhde et al, 1984). Thus, as Murray (1988) points out, the relationship of anxiety to coffee-caffeine use is complex in both normal and psychiatric populations, suggesting the problems expressed in the chicken-egg relationship.

Regular Caffeine Usage and Cognitive Performance

The relationship between habitual caffeine consumption and cognitive ability also needs to be considered in the context of this experiment. Erikson et al (1985), for instance, found that females who habitually consume low amounts of caffeine recalled more words in a short-term memory test than females who reported higher levels of caffeine consumption. Similarly, Gilliland and Andress (1981) in a study of college students, reported that academic performance was lower for heavier users of coffee in comparison with moderate, low, and non-users.

One implication of these findings, is that the effects of experimental doses of caffeine on cognitive performance are not uniformly experienced, but are, once again, affected by each individual's history of caffeine intake. It would seem that long-term heavy coffee and tea drinking can result in the development of tolerance to some of the effects of caffeine.

However, not all research findings unequivocally support a definite relationship between regular caffeine intake and cognitive ability. A study carried out by Primavera, Simon and Camisa (1975), for instance, found no differences between high and low caffeine consumers in terms of academic performance. From these varying findings, it is plausible to postulate that the relationship between habitual caffeine consumption and cognitive ability is not a unitary one, and that it is necessary to differentiate between different types of cognitive ability when considering this relationship.

The Influence of Regular Caffeine Intake on Subject Extraversion

Also of relevance to the present study, are attempts made by some researchers to relate habitual caffeine consumption to extraversion scores, often with positive results. Bard (1975); Revelle, Amaral and Turiff, (1976); and Revelle et al (1980), for instance, all reported that the extraverts in their college samples were more likely to use coffee in stressful situations, whereas introverts preferred to relieve stress with nicotine. In contrast however, Primavera et al's (1975) study found no difference in terms of personality scores, between caffeine users and non-users. Possibly one key to explaining the difference in these findings is that the first set of experiments measured subjects' tendencies to chose one pharmacological means over another as a means of relieving stress, while the latter study distinguished merely between subjects' use or complete non-use of caffeine. Thus, two different, albeit related, behaviors were actually being investigated.

The Mechanisms via which Caffeine has Physiological Effects

Caffeine has the pharmacological effect of inhibiting phosphodiesterase, which normally breaks down cyclic adenosine-3-5-monophosphate (cyclic AMP), to its inactive end-product, 5-AMP, thus increasing the levels of cyclic AMP (Shanahan, 1982). This process has been used to explain caffeine's stimulatory effect on the central nervous system, and resultant changes in cyclic AMP. This has the effect of increasing glucose production within cells, and thus makes

available more energy to allow for higher rates of cellular activity. So, the known arousal effects of caffeine probably result mainly from caffeine-induced augmentation of cellular metabolism rates (Shanahan).

Specifically, caffeine is known to increase levels of the catecholamine neurotransmitters; particularly norepenephrine (NE) and epinephrine (EPI) (Murray, 1988). The association between increased NE and EPI levels, and the stimulation of the sympathetic nervous system, means that symptions of excitation, nervousness and anxiety can at least be partially attributed to the influence of caffeine (Charney et al, 1984; Charney et al, 1985; Murray, 1988). The anxiogenic effects of caffeine may also be mediated through the locus coeruleus and pituitary adrenal axis of the brain (Uhde et al, 1984; Murray,1988). In the final analysis however, much more experimental work is needed regarding the stimulatory influence involved with caffeine (Lee, Cameron and Greden, 1985; Udhe et al, 1984; Murray,1988).

THE LINK BETWEEN SENSORY AND COGNITIVE DIFFERENCES, ESTROGEN ACTIVITY, AND CAFFEINE CONSUMPTION

The Pharmacological Relationship between Caffeine and Estrogen

There is some experimental evidence to suggest that the effects of caffeine on females may vary according to the level of estrogen in the subject's system. For instance, the potential interactive influence of caffeine and estrogen is supported by the fact that endogenous changes in estrogen levels across the menstrual cycle result in differences in cognitive ability, just as different doses of caffeine can affect cognitive performance (Arnold et al, 1987). It is possible that the effect of caffeine on memory performance in females also varies across the menstrual cycle (Arnold et al, 1987).

Caffeine's Influence on Subject Word-List Recall and Sex Differences

Erikson et al (1985) examined the effects of caffeine on memory for supraspan word lists. Forty seven males and sixty females were administered orally either 0, 2, or 4 mg of caffeine per kg of body weight. Immediately after hearing each list, subjects were required to recall the word list. Successful performance required subjects to simultaneously encode the new words and rehearse the words in short-term memory. Thus, the task should should place heavy demands on short-term memory. Results showed that caffeine impaired female word-recall when the

words were presented at a fast rate of three words per second. In contrast, it had no influence on the recall performance of males. It was suggested by Erikson et al that caffeine may have been affecting the efficiency with which information was encoded or manipulated in working memory.

Arnold et al (1987) repeated this study, with one crucial difference. This time, female subjects were only tested during the first five days of the menstrual cycle, and were only included in the study if they were not using oral contraceptives; which contain estrogen. These controls greatly reduced the variation in hormone levels among females in the study, and provided an examination of the effects of caffeine on women when their estrogen level was at its lowest. Once again, the findings from this experiment revealed a sex difference; albeit a different one from that discovered by Erikson et al. Although at the dose rate of both 2 and 4 mg per kg of body mass, caffeine facilitated recall in females, its only effect on male performance was at 2 mg/kg, and this was to impair recall.

At this point, a comparison between the different sex-related findings of Erikson et al and Arnold et al is of interest. Of particular relevance to the present study, is the varying effect of caffeine on female subject performance, found between the two studies. In the first study, caffeine had no apparent influence on female recall when word-lists were presented at a moderate rate. In contrast, it facilitated female recall in Arnold et al's study. Moreover, these contrasting results need to be considered in view of the fact that in the first study, because subjects were used without differentiation of menstrual cycle phase, their estrogen levels would probably have varied considerably, whilst the

latter experiment attempted to impose a uniform low level of estrogen. Thus, this variance in findings from one study to another, provides further evidence for the postulation that caffeine's effect on female memory performance is mediated by the level of estrogen available. Hence,testing female subjects at different stages of the menstrual cycle, as has been done in the present study, is necessary in order to clarify this relationship.

Moreover, it is possible that the effect of caffeine changes according to the absolute level of estrogen in the body (, as suggested by Arnold et al 1987). Women with typically low levels of estrogen, for instance, may be differently affected by caffeine than women with overall higher levels of estrogen. Support for this postulated direct link is provided by the knowledge (Arnold et al, 1987) that high caffeine consumption and low levels of estrogen enhance the possibliity of osteoporosis, for example, in postmenopausal women.

THE NATURE AND SCOPE OF THE INVESTIGATION

The aim of the present study was to clarify the relationship between estrogen and caffeine regarding short-term memory recall. Arnold et al's (1987) study using only menstruating females, and male subjects, found significant sex differences associated with both dose effects and task performance. As Arnold et al point out in their study, the logical extension of this finding is to compare the performance of female subjects under the influence of different caffeine doses, at different stages of the menstrual cycle, when estrogen levels will be variant. Thus, this study was firmly based on the earlier research and findings produced by researchers such as Erikson et al (1985) and Arnold (1987).

If such research could establish that caffeine's effects on short-term memory performance are influenced by subjects' estrogen levels, then researchers would be one step closer to understanding the role of this group of hormones, and thus also fundamental sex differences, in cognitive functioning. In addition, exploration of the link between estrogen level and caffeine may provide an explanation for the differential effects of caffeine in males and females.

Subjects in this study were divided into four experimental groups dependent upon firstly, whether they were tested during days 10-14 of their menstrual cycle, when estrogen levels would be expected to be high, or during days 1-5, when estrogen levels would be presumably low. The

second variable manipulated in this experiment concerned whether subjects received a caffeine dose of 0 or 4 mg per kg of body mass. It was decided to use only these two doses, in view of Arnold et al's finding that female subjects were similarly affected by doses of 2 and 4 mg/kg. During the experimental session, subjects also completed a self-reported habitual caffeine consumption questionaire, in order to determine the influence of this variable on their experimental performance. In addition, in view of earlier findings that subjects' individual scores of extraversion, and arousal levels are interactive with caffeine effects (see the earlier part of this introduction), each subject also completed an Eysenck Personality Inventory, in order to determine their Extraversion score. Based upon the same rationale, subjects were also required to complete a State Arousal Questionaire during the session.

The Primary Hypothesis

The primary hypothesis to be tested in this experiment was the following:

Hypothesis One: That the recall performance of menstruating subjects would be differently affected by caffeine consumption than that of ovulating subjects. It was tentatively suggested that caffeine would facilitate recall more for subjects tested during the beginning of their cycles than for subjects tested at mid cycle.

The rationale behind this hypothesis was as follows. To begin with, both caffeine and estrogen have been proposed as adrenergic stimulants

(Murray, 1988; Broverman, 1981). Furthermore, the work of some researchers has shown that up to a certain level, increased arousal has a positive influence on memory performance. Beyond this point, any further increase may impair performance (Revelle et al, 1987; Broaadhurst,1959; Duffy,1972). Because menstruating women's estrogen levels are fairly low, it could be postulated that during this stage of the cycle, women are also in a relatively low state of arousal, and therefore also that their memory capacity would also be at its lowest. It is plausible to suggest that administration of caffeine to these women would facilitate their memory performance by adjusting their arousal level to a more optimum point. In contrast, women tested during days 10-14 of their menstrual cycle, when estrogen levels reach a peak; would be expected to be more aroused, and therefore to have better word-list memory capacity than during menstruation. Administration of caffeine to these women would be expected to have less of a facilitative effect, or if it increased their arousal level beyond the optimum level, might actually impair memory performance. Such a prediction is in agreement with those made by certain earlier researchers. Sommer et al (1972), for instance, predicted that in ovulatory women, the rise in estrogen levels should enhance the performance of automatised tasks. In comparison, the antagonism of progesterone to estrogen during menstruation should act to impair the performance of automatised tasks.

Additional Hypotheses

It is acknowledged that such expected findings might well be influenced by variables such as subjects' habitual caffeine intake and individual arousal levels. Thus, one would also expect to find a correlation between regular caffeine intake, Eysenck Personality Inventory Extraversion scores, and memory performance. In view of this; two secondary hypotheses have been formulated:

Hypothesis Two: That subjects classified as high extraverts in this study would exhibit better recall performance under the caffeine condition than under the placebo condition, and conversely; that subjects classified as low extraverts in this study would exhibit poorer recall performance under the caffeine condition than under the placebo condition.

The rationale behind this hypothesis is based on the findings of previous research (Revelle et al, 1976; Gupta, 1977; and Gilliland, 1976), which indicates that the administration of moderate doses of caffeine hinders the performance of Introverts and facilitates the performance of Extraverts on tasks that tax short-term memory capacity.

Hypothesis Three: That subjects classified as high caffeine consumers in this study would be differently influenced by caffeine's effect on short-term memory than subjects classified as low caffeine consumers.

The rationale behind this hypothesis is based on the results of earlier researchers, showing that some habitual users acquire caffeine tolerance (Shanahan, 1982). Moreover, the above hypothesis is in accordance with the findings of Erikson et al (1985) for example, who found that low regular caffeine users recalled more words on a short-term memory task than subjects who reported higher levels of regular caffeine consumption.

Furthermore, the experimental performance of habitual caffeine users in this study might well be affected by the presence of withdrawal symptions, resulting from the twelve hour pre-experimental caffeine abstinance which all subjects were asked to conform to. Potential caffeine-withdrawal symptions include drowsiness, lethargy, yawning, irritability, nervousness, depression and anxiety (Shanahan, 1982).

Partly in view of this, the present study included a State-Arousal Questionaire which included measures of subjects' immediate states of irritability, fatigue, depression, anxiety and subjective energy levels. Thus, comparisons were able to be made between subjects' habitual caffeine usage, and their scores on these dimensions.

CHAPTER TWO

THE EXPERIMENT

SUBJECTS

Recruitment

The total number of subjects that participated in this study was thirty eight. Subjects were recruited on a voluntary basis, from University of Canterbury Stage One and Two Psychology classes. Only female subjects were used, and subjects' ages ranged from seventeen to thirty four years, with the mode being nineteen years.

Criteria for Subject Selection

In order to enhance the possibility of being able to estimate subjects' estrogenic state, based on what menstrual phase they were at, subjects were selected according to the following criteria:

1) Only regularly menstruating subjects were used, with a cycle length between twenty five and thirty two days.

2) Subjects must not have been pregnant or been breast-feeding within the last twelve months before the experimental session.

3) Subjects were not used if they were using the contraceptive pill or contraceptive injection, or had done so within the last three months.

4) Subjects were not used if they were underweight or more than 30% overweight, (according to Metropolitan Life Insurance Tables (1983) which give an acceptable range of weights according to height and body frame size).

5) In addition, subjects were not included in the study if they reported any cardiovascular problems, epilepsy, hypertension, migraine headaches, ulcers, diabetes, kidney disorders, seizures or blackouts, allergies to caffeine, or if they reported taking any medication on a regular basis.

ASSIGNMENT TO GROUPS

Subjects were randomly divided by menstrual cycle phase (,either tested during days 1-5 or days 10-15 of the cycle), and caffeine dose (0 or 4 mg of caffeine per kg of body mass,) into four groups. The numbers of subjects in these four groups were eight, nine, ten and eleven.

After the experimental session, based on the results from their habitual caffeine consumption questionaires, subjects were also classified according to a criterion of 'high' caffeine consumption (defined arbitrarily as being four or more cups of tea and coffee, or three cups of coffee, daily) and 'low' caffeine consumption (, defined as including less than four cups of tea and coffee, or three cups of coffee, daily).

APPARATUS

Word-Lists

The stimulus materials in this experiment were three audio-taped lists, each of twelve concrete, one-syllable nouns. Appendix Two lists the

words which were used. The words were selected from the Toronto Word Pool (Friendly, Franklin, Hoffman, and Rubin, 1982), and were all of moderate rating, regarding both imagery (the rated ease with which a word arouses a mental image), and concreteness (level of abstraction). Each list had a mean syllable range of 2.0 syllables per word.

Experimental Questionaires

Caffeine consumption questionaires (, taken from Shanahan,1982, see Appendix Three) were utilized to estimate subjects' habitual levels of caffeine consumption. In addition, a State Arousal Questionaire (, also taken from Shanahan, 1982, see Appendix Four) was completed by each subject in order to gauge subjects' mood states. Finally, during the course of the experimental session, each subject completed an Eysenck Personality Inventory, Form A., so that their extraversion score could be determined.

Mode of Caffeine Presentation

Subjects were given fruit juice based beverages to drink during the experimental session, which contained either 0 or 2 mg of caffeine powder per ml. In order to compensate for the slighty bitter taste of the caffeine powder, the placebo beverage contained a small quantity of quinine at a level insufficient to produce any pharmacological effects.

The Experimental Environment

The experimental sessions took place in a small laboratory, in a relaxed atmosphere. During the time interval between beverage consumption and experimental testing, the experimenter encouraged the subjects to feel free to read a book or engage in conversation.

THE PROCEDURE

Pre-experimental Instructions

Subjects were asked in advance, to refrain from consuming alcohol for forty eight hours; and caffeine products for twelve hours, before the experimental session. The evening before the experimental session, subjects were again reminded of this instruction.

All subjects were asked to get a minimum of five hours of sleep the night before the experimental session.

Deciding When to Test Subjects

The date of each subjects' session was determined on the basis of her report of when her last period started.

Half of the subjects were tested on one of the days ten to forteen after their last period had started. (These subjects were also given a digital clinical thermometer , and asked to take their temperature, first thing in the morning, for the next seven days. This measure was taken in an attempt to record subjects' ovulatory temperature nadir, and thus to confirm that experimental testing had taken place during the late

follicular phase of the menstrual cycle when estrogen levels reach a peak (Sanders,1981). However, due to inaccurate temperature taking on the part of many of these subjects, this measure was rendered unusable.)

The rest of the subjects were tested during one of the first five days of their menstrual cycle.

Following Arnold et al's example, all experimental sessions were conducted between 8:00 a.m. and 12:00 p.m., in order to control for diurnal variations in arousal (Arnold et al, 1987).

Instructions During the Experimental Session

At the beginning of the experimental session itself, subjects were given a beverage to drink, which they were informed might or might not contain caffeine. At this point, the procedure of the recall test, which they would complete later in the experiment, was explained to them in advance.

During the thirty minute absorption-period between beverage consumption and testing, subjects were asked to complete the Caffeine Intake and Smoking Questionaire, the Eysenck Personality Inventory, and just prior to testing, the State Arousal Questionaire.

Thirty minutes after subjects had consumed the experimental beverage, they were played one of the audio-taped lists of twelve words, with the instruction that as soon as the tape was finished, they were to write down in any order, as many of the words as they could remember. Word-lists were presented at the rate of one word every two seconds, which is considered to be a moderate rate of presentation (Arnold et al, 1987).

DEPENDENT VARIABLES

Word-List Recall

The primary dependent variable in this experiment was the number of words which subjects were able to correctly recall from the word list.

Other Dependent Variables

Subjects' scores on the state arousal questionaire.

This questionaire (, see Appendix Four), measured subjects' subjective feelings of irritability, cheerfulness, fatigue, relaxation, depression, activation and anxiety on a five point scale ranging from 'Strongly Disagree' to 'Strongly Agree'. For analytical purposes, these five points were subsequently relabelled from 1 to 5, with a score of 1 equalling 'Strongly Disagree' and a score of 5 equalling 'Strongly Agree'.

The results from the Caffeine Inake form.

This questionaire gave a self-reported estimate of subjects' habitual intake of caffeine in the various forms of caffee, tea, cocoa products, soft drinks and over the counter preparations. Subjects were also asked to report the average amount of cigarettes that they smoked daily.

CHAPTER THREE

RESULTS

WORD-LIST RECALL

Subjects' Overall Recall

Overall, subjects' mean word-list recall was 7.4 words out of a maximum of twelve words, with a standard deviation of 1.85. The modal number of words recalled was 8.

Statistical Tests Used

Because of the skewed nature of the data collected, it was decided to analyse the data using Mann-Whitney-U tests and Median tests, which are suitable for non-parametric data.

Recall as a Function of Menstrual Cycle Phase

A Median test was used to compare recall performance between subjects at different stages of the menstrual cycle. No significant difference was found.

Recall as a Function of Menstrual Cycle Phase

Combined median = 8

Early cycle median = 8, n = 17

Mid cycle median = 7, n = 21

Caffeine Effects on Recall

A median test was carried out, to compare recall performance, between subjects in the two caffeine groups. No significant difference between the 0 mg/kg and 4 mg/kg groups was found.

Recall Scores for Caffeine versus Placebo conditions

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combined median = 7.5

caffeine condition median = 8, n = 18

placebo condition median = 7, n = 20

Recall in Relation to Both Menstrual Cycle Phase and Caffeine Dose

It was discovered that for the subjects who were tested during early-cycle, no significant recall difference between placebo and caffeine conditions was found. In comparison, for subjects who were tested during mid-cycle, a significant recall difference ($p \leq 0.05$) was found between the placebo and caffeine conditions.

Recall Scores for early-cycle caffeine condition versus early-cycle placebo condition:

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combined median = 8

early-cycle caffeine median = 7.5, n = 8

early-cycle placebo median = 8, n= 9

Recall Scores for mid-cycle caffeine condition versus mid-cycle placebo condition:

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combined median = 7

mid-cycle caffeine median = 8, n= 10

mid-cycle caffeine median = 7, n= 11

SUBJECTS' SELF-REPORTED REGULAR INTAKE OF CAFFEINE

Recall in Relation to Caffeine Intake

A Mann-Whitney-U test revealed that while for low-caffeine consumers, the menstruating group demonstrated a significantly superior recall to subjects tested at midcycle ($U = 27.5$, $p \leq 0.05$), this cycle phase difference was not found amongst the high caffeine consumers ($U = 40.5$). No overall significant recall difference was found between high and low caffeine consumers ($U = 146$, $n1 = 17$, $n2 = 21$).

Thus, while the first finding supports Hypothesis Three, this study fails to replicate Erikson et al's (1985) finding that low-caffeine consumers have superior recall performance to high-caffeine consumers.

Subjects' Overall Caffeine Intake Habits

Quantitative data.

Subjects' overall daily consumption of coffee ranged from 0-12 cups, with a mode of zero. Daily consumption of tea amongst subjects also ranged from 0-12 cups, again with a mode of zero.

Self-reported subject consumption of caffeine in other forms (for example, soft drinks, cocoa products and over-the-counter stimulants), was fairly low, with most subjects reporting irregular intake of these products. Regular consumption of cocoa products, for instance, was reported by only five of the thirty eight subjects. (See Appendix Five.)

Table One

Modal Scores And Ranges Of Subjects' Reported Overall Daily Consumption Of Tea And Coffee (in cups).

Condition	Mode Scores	Ranges
Tea Consumption	0	0-12
Coffee Consumption	0	0-12

Qualitative data.

The Regular Caffeine Intake questionaire included the following questions: (1) " Does your tea/coffee drinking fluctuate according to your mood? " and (2) " If so, when do you drink more tea/coffee? "

In answer to the first question, five out of the seventeen 'high' caffeine consumers, and six out of the twenty one 'low' caffeine consumers answered "Yes" with regard to tea drinking. With reference to coffee consumption, eleven out of the seventeen of the 'high' caffeine consumers and three out of the twenty one 'low' caffeine consumers answered "Yes" to the first question.

Table Two

The Percentage Of Subjects Who Reported Changes In Caffeine Consumption According To Mood: A Comparison Of Tea And Coffee Consumption Across High And Low Caffeine Consumers.

Condition	High Caffeine-Consumers	Low
Change In Tea Consumption	29 (n=5)	29 (n=6)
Change In Coffee Consumption	65 (n=11)	14 (n=3)

Thus, 'high' caffeine consumers are more likely than 'low' caffeine consumers to alter their coffee-caffeine intake according to their mood, and the majority of all subjects report that their mood does not affect their tea consumption.

Factors which subjects indicated would prompt them into drinking more tea or coffee included boredom, emotional stress, study pressure, fatigue, depression and social situations (, see Appendix Seven for raw data).

Cigarette Intake.

Only five of the thirty eight subjects reported smoking at all, and of these, only two reported smoking ten or more cigarettes a day.

SUBJECTS' SCORES ON THE STATE-AROUSAL QUESTIONAIRE

Recall in Relation to Questionaire Scores

Median tests were carried out on each mood scale, comparing subjects who scored above the mean-recall, with subjects who scored below the mean-recall. None of these tests proved significant at the $p < 0.05$ level, with the exception of the 'Energetic and Active' scale, where subjects in the above-mean recall group tended to rate themselves as less energetic and active ($p < 0.05$), than the below-mean recall group.

Table Three

Median test results relating recall scores (divided into above and below the mean score) to mood-scale scores

	combined median	below-mean median (n) n = 21	above-mean median (n) n = 17
'Irritability'	1	1	1
'Cheerful and Happy'	4	4	4
'Fatigued and Tired'	2	2	2
'Relaxed'	4	4	4
'Depressed and Unhappy'	1	1	2
'Energetic and Active'	3	4	2
'Tense'	2	2	2

Scores in Relation to Stage of the Menstrual Cycle

Median tests were carried out, comparing subjects' mood-scores at the two stages of the menstrual cycle. Significant score differences between subjects tested during days 1-5 or 10-15 of their menstrual cycle were found for the following scales: 'Irritability' ($p < 0.05$), and 'Fatigued and

Tired' ($p < 0.01$), such that subjects tested during their periods reported being more irritable and fatigued than subjects tested at mid-cycle.

Table Four

Median Scores comparing between the two Cycle Stages for each Mood Scale

	combined median	mid-cycle median n = 21	early-cycle median n = 17
'Cheerful and Happy'	4	4	4
'Irritability'	1	1	1
'Energetic and Active'	3	3	3
'Tense'	2	2	2
'Fatigued and Tired'	2	2	2
'Relaxed'	4	4	4
'Depressed and Unhappy'	1	1	1

Scores Related to Caffeine Dosage

Median tests were carried out, comparing mood scores of subjects treated with caffeine or placebo. There were no significant score differences found between subjects who were given either a placebo or caffeine to drink.

SUBJECTS' EXTRAVERSION SCORES

Subjects' Overall Extraversion Scores

Subjects' overall median extraversion score was found to be 14.5. On the basis of this, it was arbitrarily decided for statistical purposes to classify all subjects with a score of forteen or less as low extraverts, and all subjects with a score of fifteen or more as high extraverts. The mean overall extraversion score was 13.6, with a standard deviation of 4.89.

Recall in Relation to Extraversion Scores

A Mann-Whitney U test was carried out, comparing recall scores of high and low extraverts (,classified as either under or over the median extraversion score). A significant difference was found, such that subjects with above -average extraversion scores, tended to have lower recall-scores than subjects with below-average extraversion scores ($U = 166.5$, $p \leq 0.05$).

In addition, median tests were carried out in order to see if high-extraverts and low-extraverts were differently affected in terms of recall, by which caffeine dose they consumed. It was discovered that in the case of both high and low extraverts; subjects' recall performances were not significantly influenced by whether they consumed the placebo or caffeine.

High Extravert group: $U = 31.5$, $n1 = 6$, $n2 = 13$

Low Extravert group: $U = 35$, $n1 = 7$, $n2 = 12$

Extraversion Scores in Relation to Stage of the Menstrual Cycle

A median test was carried out, comparing extraversion scores of subjects at the two stages of the menstrual cycle. No significant difference was found.

Median Scores Comparing Subjects' Extraversion Scores Between Cycle Stages:

combined median = 14.5

mid-cycle median = 16, n = 17

early-cycle median = 14, n = 21

CHAPTER FOUR
DISCUSSION

RECALL RESULTS IN RELATION TO MENSTRUAL CYCLE PHASE

The primary aim of this experiment was to investigate the interactive influence of estrogen levels and caffeine on subjects' short-term recall performance.

Overall, the results obtained from manipulating these variables were contrary to those predicted. In contrast to the original hypothesis that caffeine would have more of a facilitative influence on the short-term recall of menstruating subjects than on those at mid-cycle, the antithesis of this occurred. Subjects tested during days 10-15 of their cycle had significantly better recall if they consumed a dose of 4mg/kg of caffeine thirty minutes before the testing, than if they consumed a placebo dose. In contrast; subjects tested during days 1-5 of their cycle exhibited no recall difference between placebo and caffeine conditions.

For subjects in the Placebo group, those tested during days 1-5 of their cycle had significantly better recall than those tested during days 10-15. In contrast, for subjects who received 4mg/kg of caffeine, no significant difference in recall was found between subjects at different cycle-stages.

Possible Explanations for these Findings:

In seeking to explain the above findings, there are two different issues that we need to consider, firstly the superior recall of menstruating

subjects in the placebo condition, and secondly, the fact that only the recall performance of mid-cycle subjects seemed to improve under the caffeine condition.

With regard to the first finding, one possible explanation involves re-examining the premise that women actually are less aroused during the beginning of their cycle, based partially on the common finding (, for example, Sanders, 1983), also substantiated by this study, that menstruating women report higher levels of subjectsive fatigue than at mid-cycle. However, it may well be, that despite this subjective fatigue, and despite lessened estrogen activity, women are none the less at an arousal peak during their period. (Feelings of fatigue in some menstruating females, for instance, may be attributable to slight anemia.) Support for this possiblity comes from the finding of both Sanders (1983) and the present study, that female subjects frequently report feeling more irritable during menstruation than at mid-cycle.

The possibility of a compensation process acting as a facilitative factor in the case of menstruating subjects should also be considered. Hughes (1983), for instance, raises the possibility that beliefs about menstrual cycle effects may increase subject motivation from a perceived disadvantage during menstruation, and consequently to improved performance. Thus, it is possible that in the present study, subjects tested during days 1-5 of their cycle made more effort to perform well on the memory recall test, in order to compensate for a self-perceived menstrually-related performance disadvantage.

It is acknowledged that this theory does not explain why menstruating subjects under the caffeine condition did not exhibit superior recall to mid-cycle subjects. However, given the belief of many researchers

(Murray, 1988) that caffeine makes one more alert and increases the mood-lifting catecholamine neurotransmitters, norepinephrine and epinephrine, it is possible that menstruating subjects under the caffeine condition did not perceive themselves to be at a disadvantage, and hence were not susceptible to compensatory behaviour.

In addition, if mid-cycle subjects actually were less aroused than those tested at early-cycle, caffeine may have had the straight-forward effect of increasing arousal to a more optimum level.

The possibility of other variables having an interactive influence on recall performance, also need to be considered. This is especially likely considering the small subject sizes involved in this study. Potential factors which may have influenced these results include subjects' extraversion scores and regular caffeine consumption. However, with regard to the influence of subjects' degree of extraversion, no significant link was found between extraversion and caffeine dose (see below). Like wise, rate of regular caffeine consumption was not related to recall performance, except for heavy caffeine drinkers.

Finally, it is this author's suggestion that methodological factors such as the small sample size (,see discussion of methodological issues below,) may be partially responsible for these findings.

SUBJECTS' SELF-REPORTED REGULAR INTAKE OF CAFFEINE

Recall in Relation to Caffeine Intake

Results found that for heavy caffeine users, the superior recall performance shown elsewhere in the study by menstruating subjects (,in

the placebo condition), was not exhibited. Otherwise, recall performance was not related to rate of regular caffeine consumption.

Thus, although the first finding was in accordance with hypothesis three, this study has failed to replicate Erikson et al's (1985) finding that low caffeine consumers have an overall superior recall performance to high caffeine consumers. Two suggested reasons for this latter result are, firstly, the unpredictable influence of caffeine withdrawal symptions (see Introduction) and secondly, methodological reasons (see below).

With regard to the cycle phase-caffeine intake interaction, the following rationale is offered: If we assume that the overall cycle phase difference is partly attributable to heightened physiological arousal during menstruation,then the disappearance of this cyclical advantage in heavy caffeine consumers may possibly be due to over-arousal to the point of recall impairment, in these menstruating subjects. It is also possible that heavy use of caffeine during menstruation has other, detrimental side-effects (, such as aggravating menstrual pain), which might impair recall performance.

Subjects' Overall Caffeine Intake Habits

Apart from a few exceptions (, see Appendix Five), the subjects in this study reported relatively low regular intake of caffeine products. This finding is in contrast with American figures, whom Greden et al (1978) estimates as consuming about six or more cups of coffee per head, daily. Moreover, it is also considerably lower than the figures reported by some other New Zealand researchers. New Zealand Statistics Department

figures for 1982 (Shanahan, 1982) and 1986 (Fenn, 1986) for instance, reported that New Zealanders were consuming on average, two to three caffeine-containing drinks daily. In comparison, a large proportion of the present study's subjects reported drinking no tea or coffee on a daily basis.

Similarly, many more subjects in the present study reported consuming no caffeine on a regular basis than did subjects in a similar survey carried out by Shanahan (1982). Specifically, only 18% of her female subjects reported drinking no coffee on a daily basis, compared to 37% of the subjects in the present study, and only 28% of her female subjects reported nil tea consumption, compared to 55% of the subjects in the present study.

New Zealand Statistics Department figures support the suggestion that New Zealanders' consumption of caffeine has decreased over the last seven years. For instance, Shanahan (1982) quoting Statistics Department figures for that year, reported that New Zealand's total annual import of coffee for the twelve months ending 30th of June, 1982, was 7,336,500 kgs. In comparison, the figure for the year ending 30th of June, 1989, was 5,355,697, a significantly lower amount.

It is plausible to suggest as one contributing reason behind this consumption difference in over the space of seven years, that, given the increasing general public awareness of the detrimental effects of heavy caffeine usage, people are consciously consuming less caffeine for health-related reasons. The increased cost of coffee during this period may also be affecting consumption habits.

Regular Caffeine Intake: Qualitative Data

There are two findings of interest here: firstly, that subjects are more likely to alter their coffee consumption than their tea consumption in response to mood change, and secondly, that high consumers of caffeine are more likely than low consumers to alter their intake according to mood.

It is interesting to note the factors which subjects mention as prompting them to drink more tea or coffee, such as boredom, emotional stress, study pressure, fatigue and depression (see Appendix Seven). It is suggestive from these, that subjects are self-medicating their feelings of depression, fatigue etc with caffeine. These findings are similar to those of Shanahan (1982), who reported that of her student sample, 25% of female coffee drinkers and 19% of female tea drinkers increase their consumption when under stress, and 56% of female coffee drinkers compared to 19% of female tea drinkers increase their intake during examination times and when they have a heavy workload.

Moreover, it is interesting that both in the present study and in Shanahan's, high consumers of coffee (, as opposed to tea drinkers and low caffeine consumers), are most likely to exhibit this behaviour pattern. The possible reasons behind this pattern are numerous. It could be for instance, that while low consumers of coffee have chosen to alleviate their unpleasant mood-states via some other means, high caffeine consumers have for some reason, chosen to use coffee to do so. This suggestion is supported by Greden's (1979) finding that 22% of high caffeine consumers in his study reported that caffeine made them feel "less depressed".

The concept of individual variation in response to caffeine may also have some relevance here. Research findings indicate that there are individual differences in tolerance to caffeine; possibly due to differences in caffeine's metabolic half-life (Horning et al, 1977), and differing rates of absorption (Robertson et al, 1978). It is possible to infer from this, that high caffeine consumers either have a higher tolerance to caffeine and therefore need more of the drug than typical low consumers in order to obtain the same effect; or alternatively, that high caffeine consumers are more sensitive to the mood-lifting effects of caffeine and therefore are more likely than low consumers to rely on it for such effects. Such possibilities are of course, currently speculative, but may have potential in explaining individual variation in caffeine consumption habits.

Interestingly enough, this tendency for high caffeine consumers to alter their intake according to their mood-state did not correlate with subjects' extraversion scores, in keeping with the results of Primavera et al's (1975) study, which also found no difference in terms of personality scores; between caffeine users and non-users. Another possible relationship involved with this finding, is that high caffeine consumption causes some of the very symptions which heavy users are seeking to alleviate with it. If this is indeed the case; then heavy users of this drug may be locking themselves into a vicious cycle, where continuous ingestion of caffeine serves to aggravate their already-negative mood states. In support of this postulation, there exists a substantial body of literature linking chronic, high, caffeine consumption to mood states such as depression and anxiety. With regard to depression for instance, studies carried out by Greden et al (1977); Neil et al (1978) and Kupfer et al (1975), have demonstrated significant links between depression and heavy,

long-term caffeine use. Significant correlations between anxiety and high caffeine consumption have also been found by researchers such as Murray (1988). Interestingly enough however, subjects' mood-scale scores in the present study did not correlate significantly with regular caffeine intake (, see below).

Obviously, this postulation is purely speculative at present since it is still uncertain for instance, whether heavy caffeine use causes mood states such as anxiety and depression,is the result of them, or is coincidental to them.

SUBJECTS' SCORES ON THE STATE-AROUSAL QUESTIONAIRE

Recall in Relation to Mood-Scores

The only mood-scale result which was significantly related to subject recall, was the finding that subjects in the above-mean recall group tended to rate themselves as less energetic and active than did the subjects in the below-mean recall group.

The implications of this finding are interesting, in light of the earlier-discussed theory that too much physiological arousal impairs short-term memory recall. It would seem that a moderate, as opposed to a high subjective feeling of energy, is optimum for short-term memory performance.

Menstrual Cycle Phase in Relation to Mood Scores

The only mood-score results which were found to relate to menstrual cycle phase, were the findings that subjects tested during menstruation reported being more irritable and fatigued than subjects tested at mid-cycle.

These results are especially interesting in view of the finding that subjects tested during menstruation had better recall performance than subjects tested at mid-cycle, and the subsequent suggestion that menstruating subjects in this study may have been more aroused than subjects at mid-cycle. As has already been postulated (see earlier on in the discussion), subjective feelings of irritability on the part of menstruating subjects may indicate that despite simultaneous feelings of fatigue, these subjects were experiencing higher levels of physiological sensitivity than subjects tested at mid-cycle.

The finding that subjects tested during days 1-5 reported a higher level of fatigue also deserves comment, in light of the simultaneous finding that these same subjects showed no recall improvement under the caffeine condition. This combination of results is in contrast to the finding of some other researchers (, for example Dews (1982) and Mitchell et al (1974), that when performance lags under fatigue, a pick-up traceable to caffeine can be measured. One explanation for this difference in findings may stem from the possibility that, even though menstruating subjects' fatigue scores in this study were significantly higher than those of subjects at mid-cycle, they were still not sufficiently low as to respond beneficially to caffeine effects.

With regard to the absence of a significant finding between cyclical phase

and the other mood ratings, this finding is in accordance to that found in similar investigations by Sanders et al (1983) and Gamby (1989), thus supporting the conclusion drawn by Sanders (1983), that individual variation is a prominant feature in mood ratings.

Experimental Caffeine Dose in Relation to Mood Scores

Subjects' mood-scores were apparently unaffected by whether subjects had been given caffeine or a placebo to drink. These findings are in contrast to those reported by Ritch, 1970, Lienert and Huber, 1966, Barmack, 1940, Goldstein et al, 1965, and Clubley et al, 1979, who reported beneficial effects on arousal and mood after consumption of small to moderate doses of caffeine. Battig and Buzzi (1986), however, also found no significant mood changes related to caffeine consumption. It is suggested that the effects of caffeine on mood are not a simplistic, universally-experienced, phenomenon, but rather, are interactive with other influences impinging on the individual.

Mood-Scale Scores Related to Habitual Caffeine Intake

There were no significant score differences found between subjects who were classified as either 'High' or 'Low' caffeine consumers. This result, once again, is contradictory to the findings of some other researchers. Murray (1988), and Greden et al (1980) for example, both found a significant correlation between state-anxiety and high caffeine caffeine consumption.

However, as was mentioned in the Introduction, the relationship between

subject-mood and habitual caffeine use is acknowledged by researchers such as Murray to be a complex one,with somatic symptions of anxiety, for example, being reported more commonly by low caffeine consumers (Boulenger, Uhde et al, 1984). As Shanahan (1982) points out, it is quite possible that the high caffeine consumers in the above-cited study, were anxious before beginning caffeine consumption. Additionally, as has already been mentioned earlier in this discussion, it is possible that high caffeine consumers may be simply responding to a naturally higher tolerance level to caffeine, and actually be receiving no more subjective effect from it than low consumers.

SUBJECT EXTRAVERSION SCORES

Subjects' Overall Extraversion Scores

Subjects' overall mean extraversion score was found to be 13.6, with a standard deviation of 4.89. This value is noticeably higher than the mean student extraversion score attained by Eysenck in 1964 (Eysenck aand Eysenck, 1964), which was 11.09, standard deviation 4.54. There is no way of knowing, from this small pool of data, whether this apparent rise in student extraversion over the space of 25 years, actually represents a real difference or not. It is always possible that University of Canterbury psychology students are a particularly extraverted sub-sector of the student population. It is also possible that extraverts are more likely to volunteer as subjects for psychology experiments, and that New Zealand extraversion norms differ from those obtained overseas.

Recall in Relation to Extraversion Scores

It was found that subjects with above-average extraversion scores, tended to have poorer recall than subjects with below-average extraversion scores. This result is in keeping with most research findings that introverts tend to perform better academically than extraverts (Lynn, 1971). It has been found, for example, that students who do well at university have lower extraversion scores (Broadbent, 1958; Furneaux, 1957). However, it is also in contrast to findings by Howarth and Eysenck (1968), and Kleinsmith and Kaplan (1963, 1964), that extraverts are superior at paired-associate recall at short-term intervals. It would seem that different types of recall tasks (, that is, straight-forward item recall as in this study, as opposed to paired-associate recall in the latter-quoted studies), are involving different cognitive processes.

Moreover, it was also found in this study, that in the case of both high and low extraverts, subjects' recall performances were not significantly influenced by whether they consumed the placebo or caffeine.

This latter finding is in contradiction to reports from other researchers that moderate doses of caffeine hinders the short-term memory performance of introverts and facilitates the same performance of extraverts (Revelle et al, 1987; Eysenck, 1968), and thus also, Hypothesis Two which predicted that caffeine would facilitate the recall of extraverts and impair the performance of introverts. Again, this discrepancy in findings can be explained via the different demands placed on subjects in varying recall tasks.

Menstrual Cycle Phase in Relation to Extraversion Scores

No significant relationship was found between menstrual cycle phase and subjects' extraversion scores. This result is in keeping with Eysenck's view that extraversion is a stable trait phenomenom (Deaux and Wrightsman, 1984; Eysenck, 1968), and Mohan and Chopra's (1986) finding of no significant extraversion score differences between subjects tested premenstrually and post-menstrually.

CHAPTER FIVE

METHODOLOGICAL ISSUES AND SUGGESTIONS FOR FUTURE RESEARCH

Subject Sample Size

This study used a small sample size, partly because of the difficulties involved with recruiting subjects who satisfied all the criteria for subject selection. Thus, the sample size may not have been large enough to demonstrate actual population differences.
In light of this, future studies should incorporate much larger sample sizes than the one used here.

The Experimental Design

The once-off nature of the experiment may not have been enough to be able to gauge some of the actual differences that occured between subject groups.
Obviously then, the need is there for a researcher with more time and resources to repeat testing over a more sizable time-frame, such as several menstrual cycles, and to compare cycle-related differences, not only between subjects, but also within subjects.
The design of this experiment may have also been weakened by the fact that subjects were only tested on their recall of one word-list, whereas

testing their performance on a greater number of lists would presumably have given a more reliable measure of their recall ability.

Hormonal-Testing Techniques

Furthermore, the resource-restrictions applicable to this particular study, excluded the use of sophisticated hormone testing techniques. Rather, estrogen levels in this study were estimated as being 'high' or 'low' according to subjects' self-reports of whether they were at the beginning or the middle of their menstrual cycle.

Although only subjects with self-reported regular cycles, with a cycle-length range of 25-32 days were used, determining hormonal levels via this method must inevitably be prone to error.

Subjects tested at mid-cycle were given clinical thermometers, and asked to take their temperature for seven days after testing, in an attempt to determine exactly when ovulation occured. (Ovulation is signified by a slight temperature drop.) However, although subjects were shown how to use the thermometers and were asked to take their temperature as accurately as possible, many subjects were unable to provide accurate temperature readings, thus rendering this attempt to fine-tune hormonal estimates futile. Ideally, any research of this nature, should incorporate the use of more accurate hormone testing techniques than were used in this study.

Pre-experimental Subject Stimulant Consumption

Similarly, although subjects were asked to refrain from alcohol consumption for twenty four hours, and caffeine consumption for twelve hours before the experimental session, it is possible that not all subjects adhered to this instruction, thus altering their experimental performance. In particular, caffeine consumption by some subjects during the hours immediately prior to the experimental session may have affected their recall performance and their ratings on the mood scales. Unfortunately, short of monitoring subjects' every move for the twelve hour period before testing, there is no real way of gauging to what extent subjects failed to follow this instruction.

Similarly, the habitual caffeine consumption habits of subjects were measured through the use of a self-report questionaire. Again, the accuracy of this variable can not be guaranteed, a factor which may have affected experimental findings. One possible, although time-consuming means of improving this accuracy, would be to ask subjects to keep daily records of caffeine intake for two or three weeks prior to the experimental session. However, even this measure can not be considered to be totally error-free.

Placebo Effects

A further methodological issue which needs to be considered, concerns the possible influence of a placebo-effect in the present study. It has been suggested by earlier researchers (, for example Murray, 1988), that the

placebo effect pervades many phases of caffeine's effects. For instance (Murray, 1988), subjective feelings of alertness following coffee-caffeine ingestion often are not accompanied by changes in objectively measured performance.

In the present study, because of ethical considerations, it was decided to inform subjects before the experimental session that the beverage they would consume, might or might not contain caffeine. In light of this, it is quite possible that significant proportions of placebo-condition subjects were convinced that they had been given caffeine to drink, with the converse being equally probable of the actual caffeine group. Although no formal monitoring of subjects' beliefs about which caffeine solution they had consumed was undertaken, most subjects were asked verbally by the experimenter, just before debriefing, whether they believed that they had consumed caffeine or not. Interestingly, a large number did have erroneous beliefs about what they had received.

Because this phenomenom was not documented, it is impossible to say just what influence it may have had on the various dependent variables measured in this experiment.

Subjects' Beliefs Relating to Menstruation

Related to the above issue, is the question of to what extent subjects' beliefs about the menstrual cycle affected their experimental performance. As mentioned earlier in the discussion, past researchers, for example Hughes (1983), have raised the possibility that beliefs about menstrual cycle effects may actually cause menstruating subjects to try harder on tasks, in order to compensate for a perceived disadvantage.

Linked to this, is the possibility of psychology students being particularly aware of the concept of menstrual performance-impairment (Hughes, 1983), and the related possiblity of women who are aware of their own changeability, being more likely to volunteer for research relating to the menstrual cycle (Sanders 1981).

Ideally then, subjects in this study should not have been questioned about their cyclical phase until after all the dependent variables had been collected, in order to avoid their focus being directed onto their menstrual state during testing. However, because it was crucial to obtain adequate numbers of both menstruating and mid-cycle subjects, this measure would not have been feasible in a study of this size. One possible strategy which future researchers could adopt, would simply be to test a very large sample size, and then after testing, to determine the menstrual phase of each subject. However, such an approach would need to bear in mind Sommer's (1973) postulation that the use of large samples may actually mask a cyclic effect occuring in certain women.

Anovulatory Female Subjects

Another potential confounding variable in a study of this nature, is the possibility that some of the subjects were anovulatory, a factor which would affect their estrogen levels. Anovulatory cycles lack the sharp preovulatory peaks of estradiol, for instance (Broverman et al, 1981). There is, in fact good reason to suspect that this phenomenon may have been present in this study, based on the findings of other researchers. DeAllende (1956), for instance, estimates that in any sample of the menstrual cycles of healthy, regularly menstruating women, 20%-35% are

estimated to be anovulatory. The inclusion of this large a proportion of anovulatory subjects in the present study, would obviously have had a substantial influence on subject performance.

The Implications of Only Using Subjects With Regular Cycles.

This study only included subjects with regular menstrual cycles, in order that inferences about underlying hormonal states might be made. However, this systematic exclusion of women with irregular cycles may have actually decreased the possibility of obtaining menstrual cycle-related effects. Hain et al (1970), for instance, found cyclical irregularity to be associated with premenstrual and menstrual symptomology.

CHAPTER SIX

CONCLUSION

From the results of the experiment, it seems clear that there is no simple interrelationship between subject caffeine intake, estrogen levels and short-term recall. Because subject arousal levels, which play an important underlying role in this issue, are influenced by so many internal and environmental factors; individual variation seems to be the rule rather than the exception, in describing this interrelationship. Thus, this particular study, cannot with any confidence, point to the finding of any definite relationship between subject performance on recall tasks after caffeine consumption, and subject estrogen levels. However, it has highlighted some of the problems involved with research of this nature, so that the following suggestions for future research can be made.

1. Because the extraneous variables involved here are so numerous, it is clear that any further studies of this type would inevitably need to incorporate correspondingly larger sample sizes than were used in this experiment, as well as implicating more powerful means of gauging subject recall ability, and ideally comparing cyclical-related recall ability within subjects.

2. Because it is believed that subject expectancy may have featured as a confounding variable in this study, future researchers, while simultaneously heeding ethical considerations, would be advised to adopt appropriate strategies for avoiding this influence.

3. Additionally, future researchers would do well to take serious consideration of any uncontrolled-for chemical substances that subjects may be consuming, prior to the experimantal session. This study excluded any subjects who were taking medication. However it cannot guarantee to have completely controlled for other substances such as caffeine, alcohol or illicit drugs.

4. Finally, it is this researcher's suggestion that future studies of the interrelationship between sex hormones, caffeine and cognitive performance, incorporate the role of the male hormone, testosterone. Testosterone has also been postulated to act as an adrenergic stimulant (Broverman et al, 1981), and may facilitate certain types of cognitive performance in males, such as perceptual-restructuring tasks, where males seem to have a natural superiority, in a similar fashion to estrogen's influence on female automatisation superiority.

Therefore, it is the opinion of this researcher, that the contribution that this study has made to the research literature, is to function as a pilot study, highlighting the issues and problems involved with research of this kind. It is also her opinion, that the primary issue raised in this study, namely, the factors underlying sex-differences in cognitive performance, is worthy of future research.

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APPENDIX ONE

SUBJECTS' RECALL SCORES DIFFERENTIATED ACCORDING TO CYCLE-PHASE, CAFFEINE DOSE, EXTRAVERSION SCORES AND REGULAR CAFFEINE INTAKE.

MID-CYCLE SUBJECTS

4 MG CAFFEINE/ KG DOSE				0 MG CAFFEINE/ KG DOSE			
ABOVE-MEAN EXTRAVERSION		*BELOW-MEAN EXTRAVERSION*		*ABOVE-MEAN EXTRAVERSION*		*BELOW-MEAN EXTRAVERSION*	
REGULAR CAFFEINE INTAKE							
HIGH	*LOW*	*HIGH*	*LOW*	*HIGH*	*LOW*	*HIGH*	*LOW*
9	8	8	7	8	6	7	7
7	9	8	5	6	7	7	9
			8		5		6
			8		7		

EARLY-CYCLE SUBJECTS

4 MG CAFFEINE/ KG DOSE				0 MG CAFFEINE/ KG DOSE			
ABOVE-MEAN EXTRAVERSION		*BELOW-MEAN EXTRAVERSION*		*ABOVE-MEAN EXTRAVERSION*		*BELOW-MEAN EXTRAVERSION*	
REGULAR CAFFEINE INTAKE							
HIGH	*LOW*	*HIGH*	*LOW*	*HIGH*	*LOW*	*HIGH*	*LOW*
6	7	4	8	6	9	8	8
		8	10	8	9		
		10		9	8		
		7			6		

APPENDIX TWO: THE WORD-LISTS USED IN THIS STUDY

LIST ONE: honey, kitchen, infant, captain, garment, hammer, cottage, dragon, pepper, salad, student, palace.

LIST TWO: lemon, hotel, lawyer, pilot, police, turkey, candle, author, table, ocean, novel, body.

LIST THREE: helmet, olive, insect, bedroom, farmer, arrow, apple, willow, button, parcel, lady, letter.

APPENDIX 3

UNIVERSITY OF CANTERBURY DEPARTMENT OF PSYCHOLOGY

A SURVEY OF CAFFEINE INTAKE (AND SMOKING) AMONG STUDENTS

Date of Birth: .....

Sex: Male ( )
Female ( )

Degree studying for .....

SECTION A.

Coffee Drinking

If you drink coffee answer the following questions and tick the appropriate response categories. If you don't drink coffee then go on to Section B.

N.B. 1 cup refers to one standard-sized breakfast cup.

1. What is your typical daily intake of coffee?

Irregular (less than daily) ( )
1 - 3 cups a day ( )
4 - 7 cups a day ( )
More than 7 cups a day ( )
(Please specify) .....

2. Please indicate how much coffee you usually drink next to the following times.

Breakfast ..... cup(s)
Morning tea ..... cup(s)
Lunch ..... cup(s)
Afternoon tea ..... cup(s)
Dinner ..... cup(s)
Supper ..... cup(s)
Other (please specify): .....
.....
.....
.....

3. Does your coffee drinking fluctuate according to your mood? (eg. does it increase with exam-time stress)

Yes ( )
No ( )

4. If so, when do you drink more coffee? .....
.....
.....
.....
.....

SECTION B

Tea Drinking

If you drink tea, please answer the following questions and tick the appropriate response categories. If you don't drink tea, then go on to Section C.

1. What is your typical daily intake of tea?

Irregular (less than daily) _____ ( )
1 - 3 cups a day _____ ( )
4 - 7 cups a day _____ ( )
More than 7 cups a day _____ ( )
(Please specify) ..... ( )

2. Please indicate how much tea you usually drink, next to the following times.

Breakfast .....cup(s)
Morning tea .....cup(s)
Lunch .....cup(s)
Afternoon tea .....cup(s)
Dinner .....cup(s)
Supper .....cup(s)
Other (please specify).....
.....
.....
.....

3. Does your tea drinking fluctuate according to your mood?

Yes ( )
No ( )

4. If so, when do you drink more tea? .....
.....
.....
.....

SECTION C

Please answer the following questions and tick the response categories where appropriate.

1. What is your usual daily intake of cocoa?

Irregular (less than daily) ( )
Daily ( )
More than once a day (please specify).....( )
.....

2. Do you eat chocolate?

Less than daily? ( )
Daily? ( )
More than once a day? (Please specify) .....( )
.....

b/ please state your usual daily intake of soft drinks (type + amount)

3. Do you ever take any tablets which contain caffeine? (e.g. No-Doz, Cafergot, Migril, Ergodryl).

Yes ( )
No ( )

What tablets do you take?

.....

.....

How frequently do you take these tablets?

.....

.....

APPENDIX 4

A STATE RESPONSE SCALE.

For each of the following statements,

a. circle each letter or pair of letters which best indicates how you feel RIGHT NOW.

b. Mark along each continuum, with an 'X', the point which best indicates how you feel RIGHT NOW.

Try to express strong feelings either way, as much as possible and only use the middle 'U' category very occasionally, when you just cannot make up your mind.

SD = Strongly Disagree
D = Disagree
U = Uncertain
A = Agree
SA = Strongly Agree

eg. 'I feel sad.' SD D U (A) SA

1. I feel irritable.	SD	D	U	A	SA
2. I feel cheerful and happy.	SD	D	U	A	SA
3. I feel fatigued and tired.	SD	D	U	A	SA
4. I feel relaxed.	SD	D	U	A	SA
5. I feel depressed and unhappy.	SD	D	U	A	SA
6. I feel energetic and active.	SD	D	U	A	SA
7. I feel tense and anxious.	SD	D	U	A	SA

APPENDIX FIVE

SUBJECTS' REPORTED REGULAR INTAKE OF CAFFEINE PRODUCTS, RELATED TO SUBJECTS' CYCLE PHASE, CAFFEINE-DOSE, AND CLASSIFICATION AS A HIGH OR LOW CAFFEINE CONSUMER

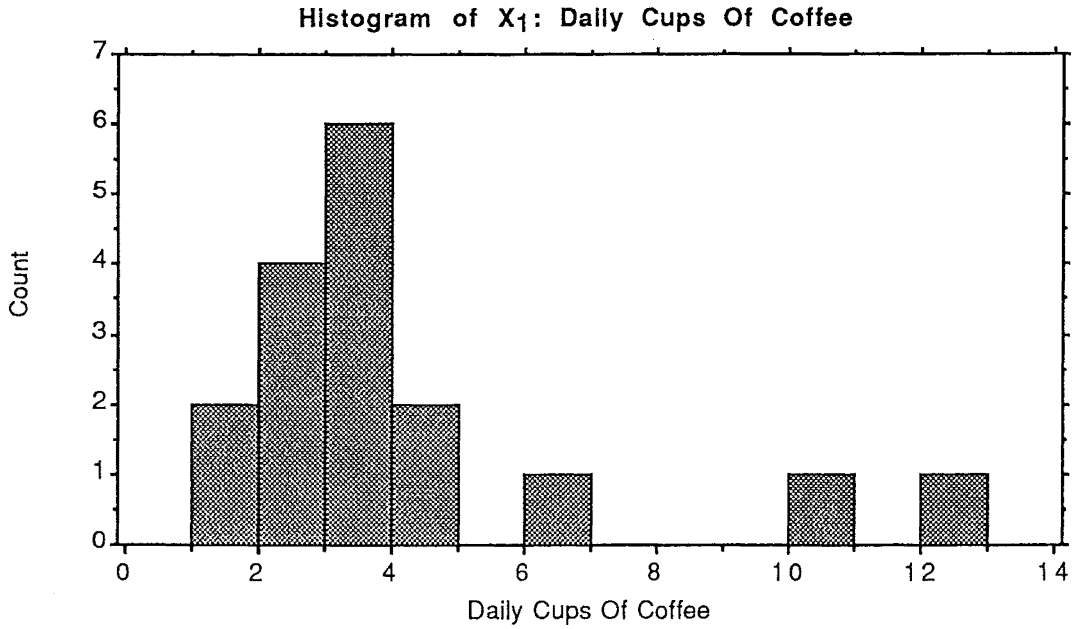
	Coffee	Tea	Cocoa-Products	Soft Drinks
Group One: Mid-Cycle, Placebo, High Caffeine Intake				
Subject				
1	10	2	0	0
2	12	0	0	0
3	3	0	0	0
4	6	1	0	0
Group Two: Mid-Cycle, Placebo, Low Caffeine Intake				
Subject				
1	0	0	0	0
2	0	0	1	0
3	0	0	2.5	0
4	1	0	1	0
5	0	0	0	0
6	1	0	0	0
7	2	0	0	0

	Coffee	Tea	Cocoa-Products	Soft Drinks
Group Three: Mid-Cycle, Caffeine, High Caffeine Intake				
Subject				
1	3	0	0	0
2	3	3	1 Pk Choc Biscuits Daily	0
3	2	12	1	0
4	1	5	0	0
Group Four: Mid-Cycle, Caffeine, Low Caffeine Intake				
Subject				
1	0	0	0	0
2	0	1	0	0
3	0	0	0	1 can diet coke
4	1	0	5	0
5	0	0	0	0
6	1	1	0	2 cups

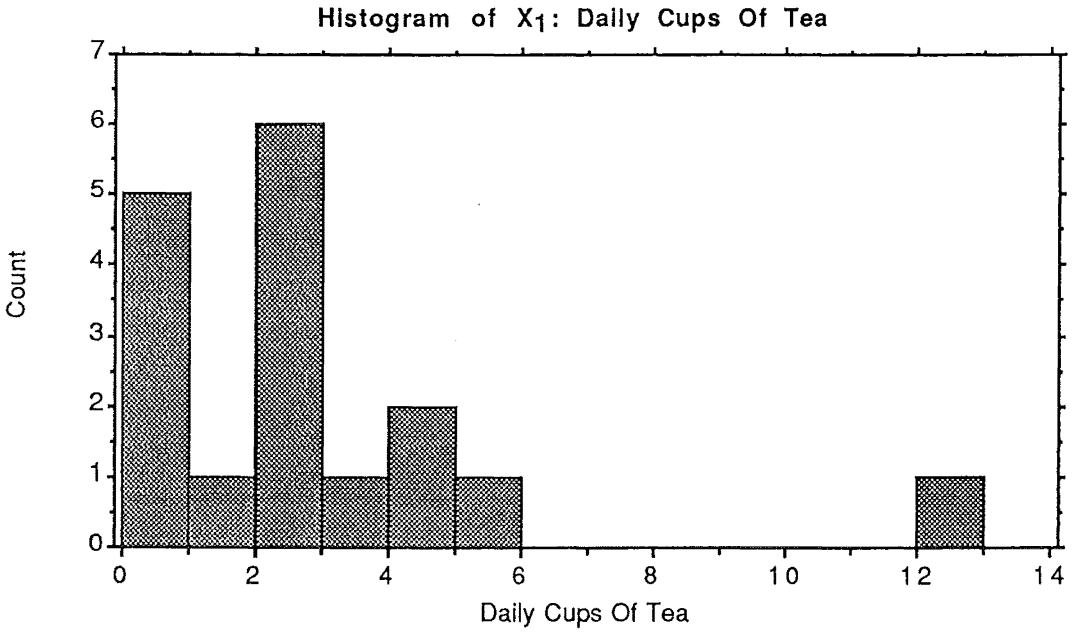
	Coffee	Tea	Cocoa-Products	Soft Drinks
Group Five: Early Cycle, Placebo, High Caffeine Intake				
Subject				
1	3	2	0	0
2	3	2	0	0
3	4	0	0	0
4	2	2	0	1 diet lemonade
Group Six: Early Cycle, Placebo, Low Caffeine Intake				
Subject				
1	0	3	1	0
2	0	0	0	0
3	0	0	3	0
4	0	0	0	0
5	0	0	0	0
Group Seven: Early Cycle, Caffeine, High Caffeine Intake				
Subject				
1	3	4	0	0
2	2	2	0	0
3	2	2	1	0
4	1	4	0	0
5	4	0	0	0

	Coffee	Tea	Cocoa-Products	Soft Drinks
Group Eight: Early Cycle, Caffeine, Low Caffeine Intake				
Subject				
1	1	1	0	0
2	1	1	0	0

Appendix Five: Figure One: Frequency Distribution of Subjects' Reported Daily Consumption of Coffee



Appendix Five: Figure Two: Frequency Distribution of Subjects' Reported Daily Consumption of Tea



APPENDIX SIX

SUBJECTS' ANSWERS TO SECTION A, QUESTION 3: 'DOES YOUR COFFEE DRINKING FLUCTUATE ACCORDING TO YOUR MOOD (E.G., DOES IT INCREASE WITH EXAM-TIME STRESS)?'

Condition	High Caffeine Users	Low Caffeine Users
No. that answered "Yes"	11	4
No. that answere "No"	6	17

APPENDIX SIX

SUBJECTS' ANSWERS TO SECTION B OF THE CAFFEINE INTAKE QUESTIONAIRE; QUESTIONS 3 AND 4

Question Three: 'Does your Tea Drinking Fluctuate According To Your Mood?"

Conditions	High Caffeine Users	Low Caffeine Users
No. of Subjects that answered "Yes"	5	6
No. of Subjects that answered "No"	12	15

APPENDIX SEVEN

SUBJECTS' ANSWERS TO SECTION A, QUESTION 4: ' IF SO, WHEN DO YOU DRINK MORE COFFEE?'

HIGH CAFFEINE USERS

"When under emotional stress-when unhappy, agitated, bored, procastinating before tasks, when drinking socially."
"When I'm under stress like an essay or assignment or exam or I'm in pain or I have a problem with a friend....."
"When I am bored at work or at home. At night, while studying for exams."
"When studying for exams or writing essays."
"When busy at work, socialising or hungry."
"During exams, when I'm bored or depressed."
"When I am working on assignments and when studying."
"When depressed, anxious or stressed."
"When run out of tea."
"When I am confined to an area e.g. sitting in a room studying, e.g. cold, wet days indoors."

LOW CAFFEINE USERS

"When I have lots of things due - as a stimulant."
"Usually when I have a lot of work on e.g. exams."
"When I'm tired and need a quick pick-me-up e.g. before periods, at social fuctions."

APPENDIX SEVEN:

SUBJECTS' ANSWERS TO SECTION B, QUESTION 4: 'IF SO, WHEN DO YOU DRINK MORE TEA?'

High Caffeine Users' Answers
"When trying to concentrate or refresh myself (e.g. feeling bogged down with work etc, therefore have a cup of tea)."
"When working, people around."
"When I'm not drinking coffee."
"When bored."

Low Caffeine Users' Answers
"When depressed or moody, near exams."
"Irregularly - just when I feel like having a change."
"When tired."
"When I have a lot of work on and I'm sick of coffee."
"When not feeling well, lazy and when cold."
"When tired."

APPENDIX EIGHT

SUBJECT CONSENT FORM

BRIEF DESCRIPTION OF THE PROJECT: You will be given a solution to drink, containing either 0 or 4 mg of caffeine per kg of body mass. (You will be blind as to which strength of caffeine you have consumed, until after the experimental session is over.) A comparison will be made as to whether subjects that are in the preovulatory phase of their menstrual cycle, are differently affected than menstruating subjects, in their ability to recall word-lists following caffeine consumption.

RISKS ASSOCIATED WITH PARTICIPATION:
Provided that you have supplied the requested information dealing with health issues such as caffeine allergies, there are no foreseen risks to you.
TIME REQUIRED: The experimental session itself will take about forty minutes maximum of your time. In addition, I may need to ask you to take your temperature, first thing in the morning, for the following seven mornings after the experimental session.

NAME OF RESEARCHER: Angela Moorhouse

NAME OF SUPERVISOR: Dr Rob Hughes

I agree to participate in the project described above, on the understanding that if at any time I wish to withdraw from the experiment I may, without prejudice, do so. All information collected will be confidental as will the identity of participants.

Signature _____
Name _____ Date _____

APPENDIX 9

HELP!!!!! HELP!!!!! HELP!!!!! HELP!!!!! HELP!!!!! HELP!!!!!

Now that I've got your attention, **I desperately need about 80 female students** to participate in a study that I am carrying out on the effects of caffeine in women, at different stages of the menstrual cycle.

What's it worth to you? Participation in this study will be painless, probably quite insightful, and each subject's name will go into a lottery, with the chance to win a $50 record voucher. In addition, you will be making a practical contribution to current research on the menstrual cycle, including the area of menstrual distress, which still badly needs a lot more investigation.

How long will it take? Subject participation time will take about one hour, and will occur after the midterm break.

SO, if you are female, and you can spare me one hour, please fill in the attached sheet. All data collected will be treated confidentially, as will the identity of the participants.

PLEASE COMPLETE ALL OF THE FOLLOWING QUESTIONS:

Name: _____

Date of Birth: ____/____/____ Phone No.: _____

(1) Are you currently taking oral contraceptives or using the contraceptive injection? _____
If not, have you done so within the last 3 months? _____

(2) Have you been pregnant and/or have you been breastfeeding within the last 12 months? _____

(3) Please state, just as accurately as you are able to, your current height and weight:
Weight = ___ kg (or ___ lbs). Height = ___ cm (or ___ ft, ___ in.).

(4) Are you menstruating regularly? _____

(5) What would you estimate your average cycle length to be (that is, the average number of days between the start of each period)? _____

(6) Do you suffer from any of the following (please circle any which you DO suffer from):
cardiovascular/heart problems, epilepsy, hypertension, migraine headaches, ulcers, diabetes, kidney disorders, seizures or blackouts, or allergies to caffeine. If you want to elaborate on this question, the following space is available for this purpose:

_____

_____

(7) Are you taking any medication on a regular basis? If so, please state type and dose (e.g., paracetamol, 600 mg once daily) and what is it being taken for?

_____

_____

Thank you for your help. Before handing in this form, please ensure that you have answered all of the questions. If I am able to use you as a subject, I will contact you within the next week.